GNSS-R GRAZING ANGLE FOR SEA ICE ALTIMETRY

R.N. Buendía *Supervisors:* S. Tabibi O. Francis
University of Luxembourg
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ABSTRACT

The grazing angle signals of opportunities from Global Navigation Satellite System (GNSS) are used to perform precise sea-ice altimetry. The novel GNSS-Reflectometry (GNSS-R) would help to better understand the sea-ice distribution and classification in the polar regions.

GNSS REFLECTOMETRY

GNSS-R uses microwave signals of opportunity for remote sensing applications, such as soil moisture, ocean winds and sea surface height.
In this contribution, Spire CubeSat constellation is used to perform precise sea-ice altimetry:

- Initially designed for Radio Ocultation (RO) applications, the CubeSats were adapt to collect direct and reflected signals at low elevation angles ($5° \leq \alpha \leq 30°$), i.e., Grazing Angle GNSS-R (GG-R).
- Strong phase coherent and Signal-to-Noise Ratio (SNR) of the reflected signal is recorded over sea-ice and inland seas under GG-R events.
- In contrast to other platforms for GNSS-R, dual-frequency measurements are available - clear advantage for the reduction of ionospheric effects.
- Spire has more than 40 CubeSats in orbit for GG-R, thus, they can provide high temporal/spacial resolution.

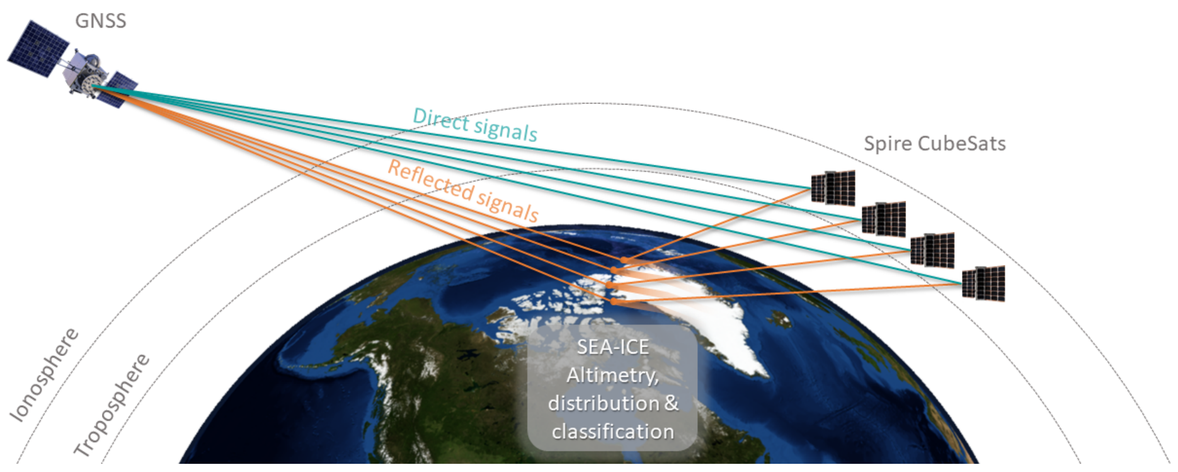

Figure 1. GNSS-R CubeSat Observations

GG-R ALTIMETRY

The GG-R altimetry relies on the geometric distance of the observed reflected signal (TXR) and the geometric differences between the direct and the reflected signal based on a reference surface.

$$\delta h = \frac{(T\hat{X}R - TR) - \Delta\hat{R}^{RD}}{2\ sin\ \alpha} \tag{1}$$

- δh: Surface height deviation from a reference surface.
- $T\hat{X}R$: Predicted reflected distance of the signal based on the reference surface.
- TR: Direct signal distance.
- $\Delta\hat{R}^{RD}$: Geometric difference between the reflected and the direct signals.
- α: Elevation angle from the Specular Point (SP).

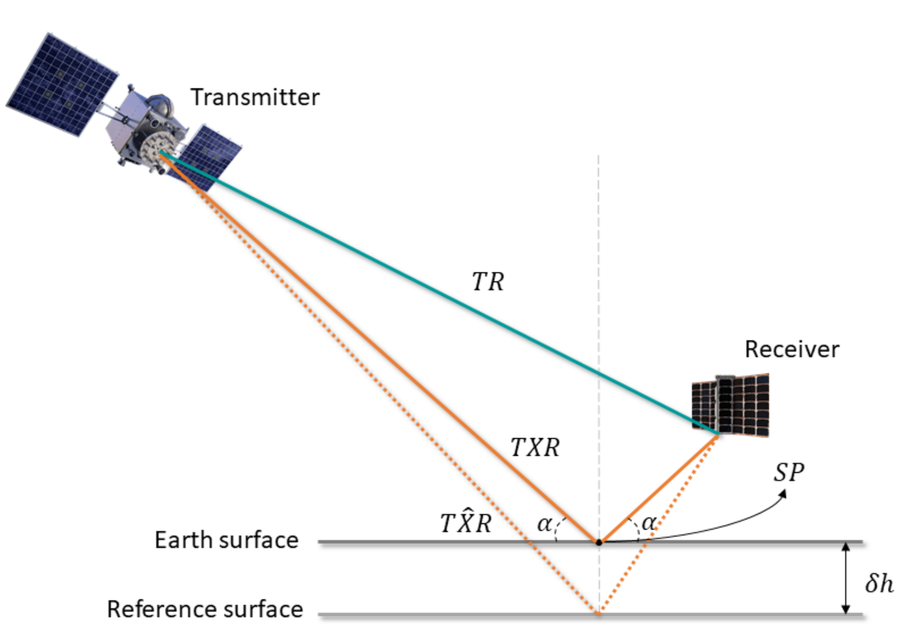

Figure 2. GNSS-R geometry and surface height deviation from a reference surface

PRELIMINARY RESULTS OVER ANTARCTICA

Surface height deviation for a two-week period (01-15 of January, 2021):

- Ionospheric effects attainable due to dual-frequency differences.
- Tropospheric delay obtained from the NCEP Global Forecast System (GFS).

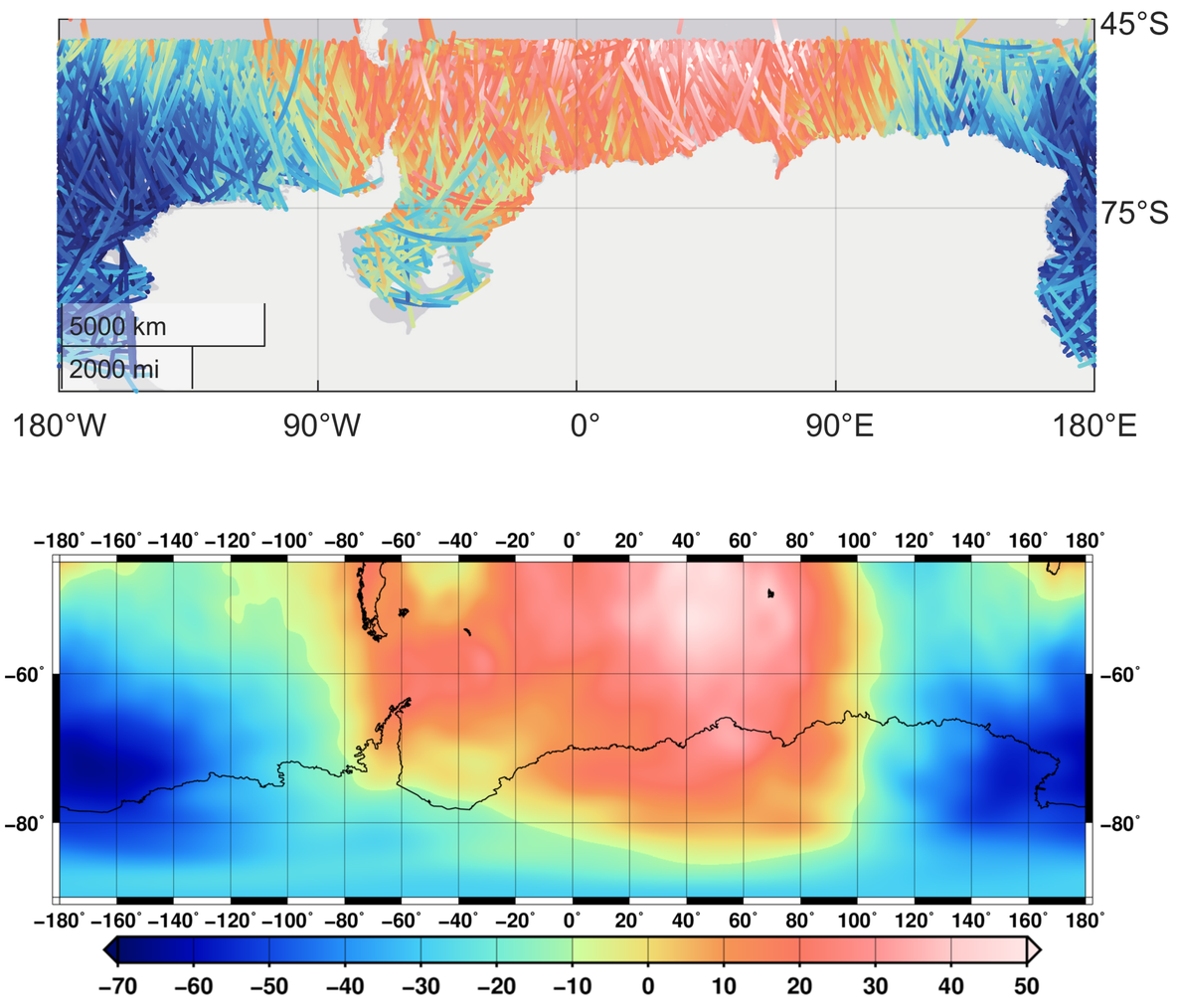

Figure 4. Surface Height Deviation (m) of the first two weeks of 2021 (up) and EGM2008 geoid reference (down)

REFLECTED SIGNALS OVER GREENLAND

- High SNR is recorded over sea-ice extend and inland seas.
- In such conditions where the reflected signal is coherent,altimetric measurements with <10cm precision can be obtained.

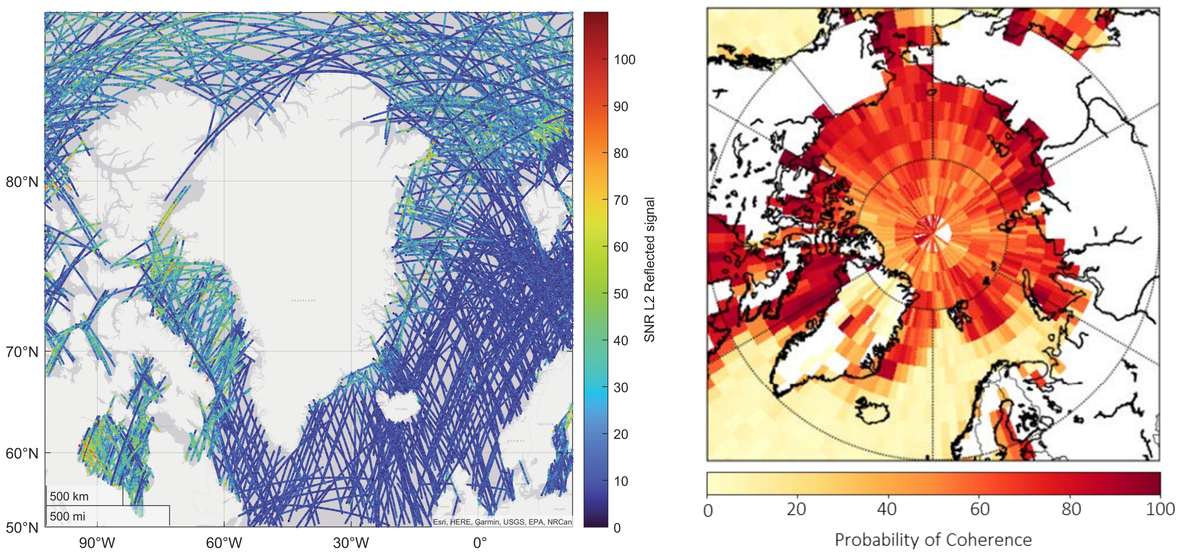

Figure 5. L2 SNR over Greenland and surroundings collected with Spire CubeSat constellation of the first two weeks of 2021 (left) and probability of coherence signal over Arctic region (right)

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